DTU Library

Diurnal and seasonal variation in air exchange rates and interzonal flows measured by active tracer gas in five Danish homes

Clausen, Geo; Bekö, Gabriel; Toftum, Jørn

Published in:
Proceedings of Indoor Air 2016

Publication date:
2016

Document Version
Peer reviewed version

Diurnal and seasonal variation in air exchange rates and interzonal flows measured by active tracer gas in five Danish homes

Geo Clausen[1*], Gabriel Bekö[1], Jørn Toftum[1],

[1]Technical University of Denmark, Lyngby, Denmark,

[*]*Corresponding email: gc@byg.dtu.dk*

SUMMARY
We measured the air exchange rates (AER) in up to six rooms in five naturally ventilated dwellings across four seasons using active tracer gas. Night time AER was also estimated in all bedrooms based on occupant-generated CO_2. Additionally, we studied the pollutant distribution across the dwellings and airflows between rooms. AERs changed rapidly during the day and differed between rooms. Occupant behavior (window opening) strongly influenced the AERs. AERs were highest in the summer, lowest in the winter. Interzonal airflow measurements indicated that the air within a given floor is well mixed, while there is less air movement between different floors. The position of the internal doors (open/closed) had a strong influence on the air movements within the dwelling.

PRACTICAL IMPLICATIONS
A better understanding of the dynamic nature of the airflows between rooms and from outdoors into the rooms can be useful for the evaluation of occupant exposure to pollutants indoors and the spatial and temporal factors affecting this exposure in residential environments.

KEYWORDS
Residences, Natural ventilation, Tracer gas measurements, Spatial and temporal variation

1 INTRODUCTION
Air exchange rate is a key parameter in understanding indoor air quality, pollutant concentrations and exposure. In naturally ventilated buildings AER will depend on building characteristics, geographic location, meteorological conditions such as indoor/outdoor temperature differences and wind speed, and occupant behavior (Yamamoto et al., 2010). Another parameter strongly influencing spatial variation in pollutant concentrations and exposure is interzonal flows within buildings. This is especially the case when localized pollution sources are present. Performing accurate AER measurements can be challenging. Various measurement methods can be chosen depending on the desired quantity of measurements, the stability of the air flows, and the experimental limitations (Persily, 2016). Detailed and well controlled measurements of air exchange rates (AER) and interzonal flows in residential environment are scarce, due to the need of sophisticated instrumentation.

2 MATERIALS/METHODS
In each season of the year continuous AER measurements were performed during 2-4 days periods, which often included weekends. An Innova 1312 Photoacoustic Multi-gas Monitor coupled with an Innova Multipoint Sampler and Dozer 1303 (Luma-Sence Technologies A/S, Ballerup, Denmark) was used. A constant concentration of 4 ppm of tracer gas (Freon®) was maintained in up to six rooms in each dwelling. For each day of the measurements the occupants filled in a questionnaire. They indicated the periods when the home was occupied

vs. unoccupied, when the windows in various rooms were open, the time they spent in the bedroom and the position of the bedroom door during the night (open/closed). The concentrations of CO_2 in the bedrooms were also measured. Before each AER measurement the distribution of a simulated pollutant from a source point across the dwelling was measured. Constant concentration of tracer gas (4 ppm) was maintained in a selected room and its concentration was monitored in the other five rooms.

3 RESULTS AND DISCUSSION

AERs changed rapidly during the day. Differences in AERs were observed between individual rooms within the same dwelling. Window opening behavior had a strong influence on the measured AERs, which were highest during occupied daytime periods, lowest in the night (Figure 1). As expected for the Scandinavian climate, AERs were highest in the summer, lowest in the winter. A moderate positive linear relationship between outdoor temperature and AER was obtained, with the coefficient of determination R^2=0.65. Significant differences were found between AERs measured by active tracer gas and CO_2. Monitoring the interzonal airflows indicated that the air within a given floor is well mixed, with the average tracer gas concentration in the non-source rooms reaching around 70% of the source room concentration. However, there was less air movement between different floors. The average tracer gas concentration in the non-source floor was less than 30% of the source room concentration. The airflow rates between rooms were highest in the summer, lowest in the winter. The position of the internal doors had a strong influence on the air movements within the dwelling.

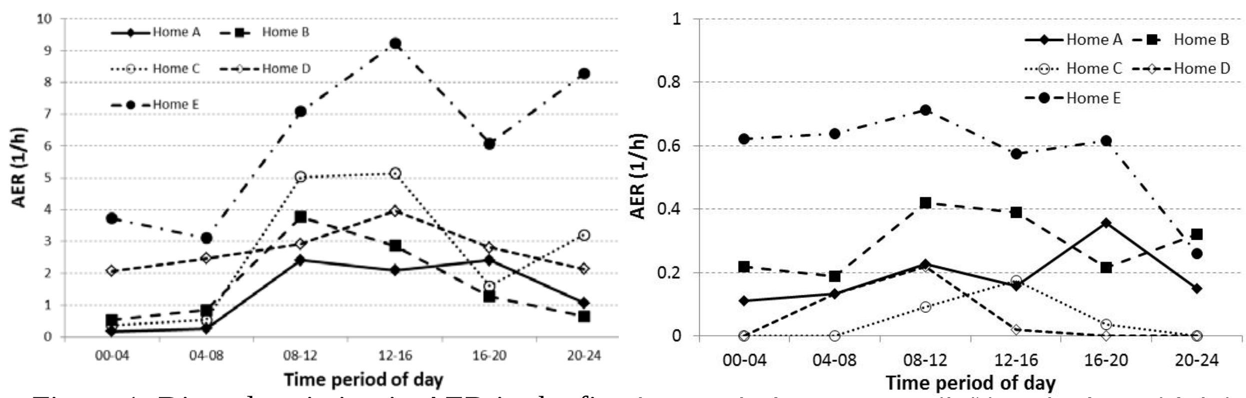

Figure 1. Diurnal variation in AER in the five homes during summer (left) and winter (right). Note the different range of the vertical axes. Each 4-hour interval is an average of the corresponding time intervals over several days.

4 CONCLUSIONS

Airflows between rooms within a dwelling as well as airflows from outdoors into the rooms can be dynamic, leading to rapidly changing AERs during the day and even differences in AERs between rooms. In naturally ventilated dwellings, occupant behavior, especially window and door opening, is a major driver of these changes and to a certain degree of the differences in AER between seasons and between dwellings.

5 REFERENCES

Persily A.K.. 2016. Field measurement of ventilation rates. Indoor Air, 26, 97-111.

Yamamoto N., Shendell D.G., Winer A.M., Zhang J. 2010. Residential air exchange rates in three major US metropolitan areas: Results from the Relationship Among Indoor, Outdoor, and Personal Air Study 1999–2001. Indoor Air, 20, 85–90.